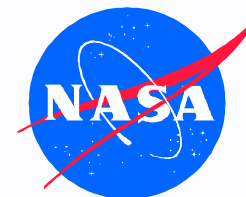
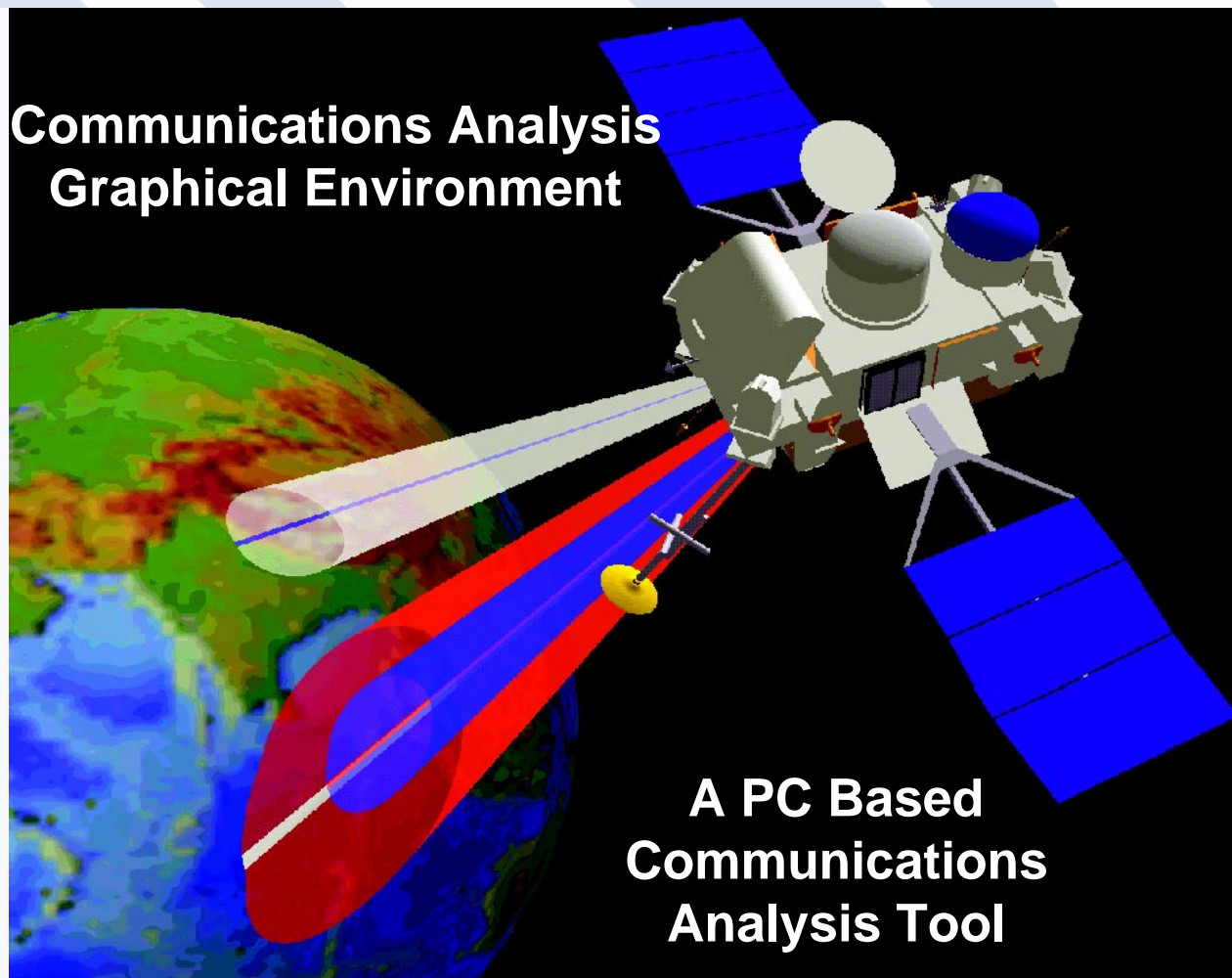


# CAGE

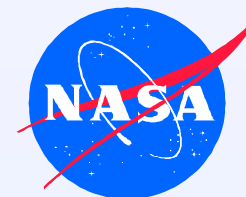


**Communications Analysis  
Graphical Environment**



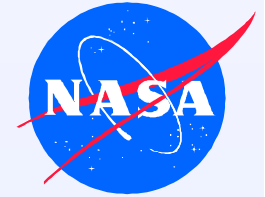
**A PC Based  
Communications  
Analysis Tool**

**Linda Harrell (STel),  
Badri Younes (NASA CLASS Project Manager)**



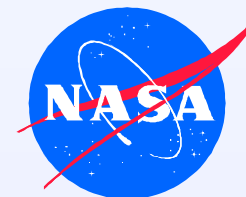
# Outline

- **Introduction**
- **Application to Ka-Band Systems**
- **Modeling Capabilities**
- **Sample Analyses**
- **Sample Output**
- **An Example**
- **PC Requirements**
- **Comparison with Other Simulation Tools**



# Introduction

- Used to design, analyze, and visualize any satellite or terrestrial communications system
- Assesses communications performance in presence of
  - interference
  - atmospherics
  - multipath
  - blockage
- Extremely versatile
  - Users define their own variables and equations
  - No need to develop or modify existing code
- Performs dynamic or static simulations



# Overview

## ■ Design

- Define communication systems using a graphical block diagram editor

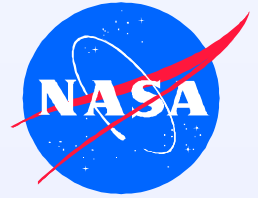
## ■ Analyze

- Geometric coverage
- Interference statistics
- Communications performance

## ■ Visualize

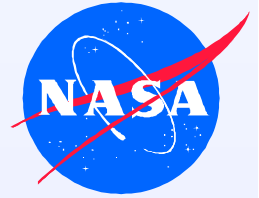
- Results displayed graphically on the screen during the simulation
- Results also stored in files

# Application to Ka-band Systems



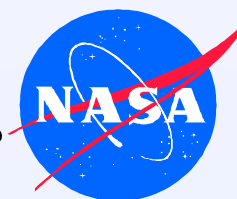
- Ideally suited for assessing performance of Ka-band systems
  - Models all different types of systems in this band
    - » Fixed Service (FS) Networks
    - » Fixed Satellite Service (FSS) Networks
    - » Mobile Satellite Service (MSS) Systems
    - » Satellite Systems that utilize Inter-Satellite links (ISLs)
  - Assesses effects of interference and rain attenuation

# CAGE Modeling Capabilities



- **Graphical Block Diagram Editing**
  - Menu driven
  - Easy to configure hierarchical systems
  - Use built-in library blocks, functions, and outputs
- **Custom Variables and Equations**
  - Makes CAGE extremely versatile and powerful
  - Users can define almost any communications or “what if” scenario using standard functions
- **Block Arrays**
  - Allows users to easily define multiple elements within a network (i.e. a network of LEO satellites or FS stations)

# Graphical Block Diagram Editor



Menus &  
Button Bars

Configurable  
I/O Ports

User Defined  
Links

Quick Help

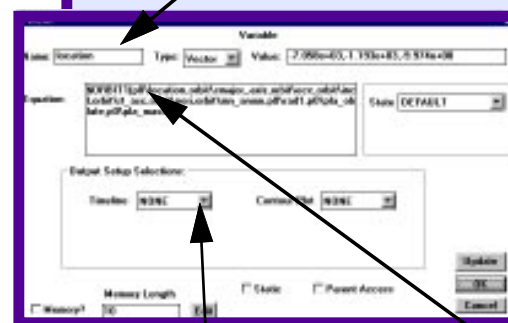
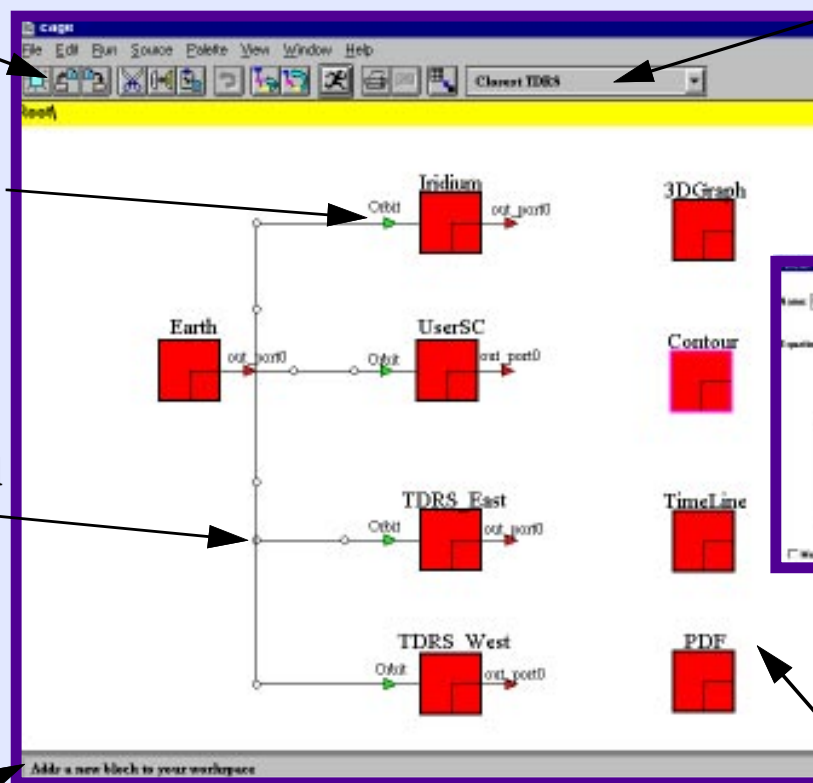
Finite State Machine  
Support

User Defined  
Variables

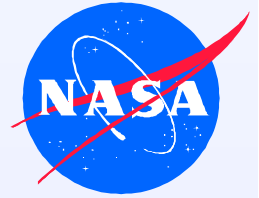
Easy Link  
to Output

Custom  
Equations

Block Diagram  
Editing



# CAGE Modeling Capabilities



## ■ Finite State Machines

- Defines communication parameters differently for different situations within a simulation
- Ideal for defining scheduling of communications services, antenna switching, or flight dynamics

## ■ Time Based Schedules

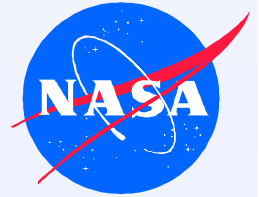
- Schedules can be read in from an input file

## ■ Antenna Patterns

- Specify antenna patterns with input files
- Select standard analytic antenna types



# CAGE Modeling Capabilities



## ■ Vehicle Dynamics

- trajectory and orbit blocks define spacecraft, aircraft, or ground vehicular motion
- Can also read dynamics from a data file

## ■ Interference

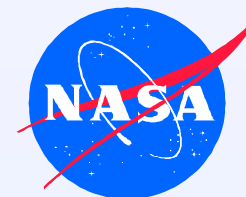
- Models solar interference, multipath, RFI, self-interference, and any other interference sources

## ■ Propagation

- Models atmospheric attenuation, rain attenuation, multipath, blockage, horizon masks, and space loss

## ■ Communications Links

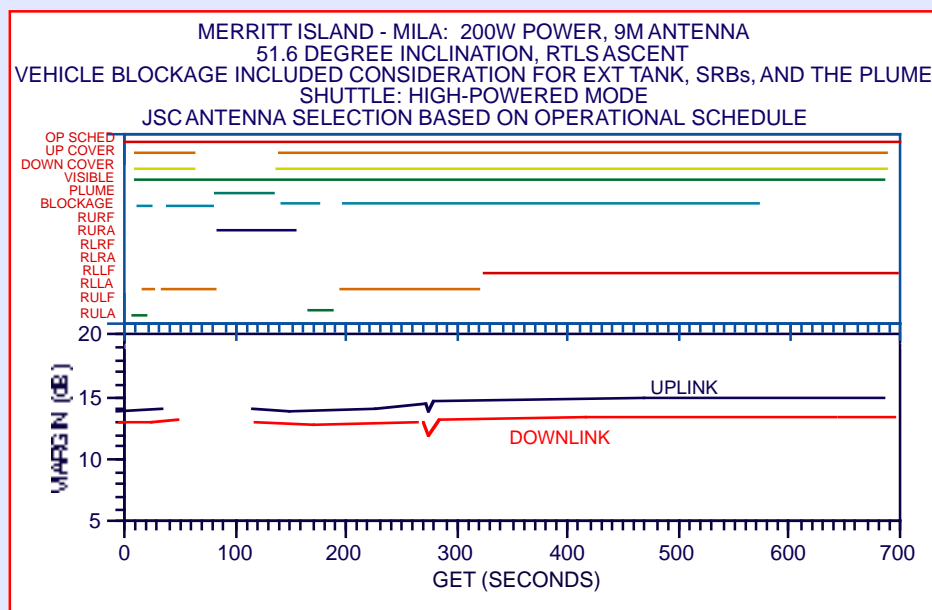
- CAGE calculates received carrier power, interference power, C/N ratio,  $E_b/N_0$ , BER, G/T or any other system parameter

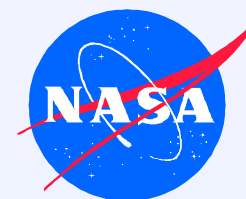


# Sample Analyses

## ■ Geometric Coverage

- CAGE can calculate look angles, view periods, antenna coverage, or solar offpointing angles
  - » even when a spacecraft is being launched, switching its antennas, tumbling, or reacting to an emergency

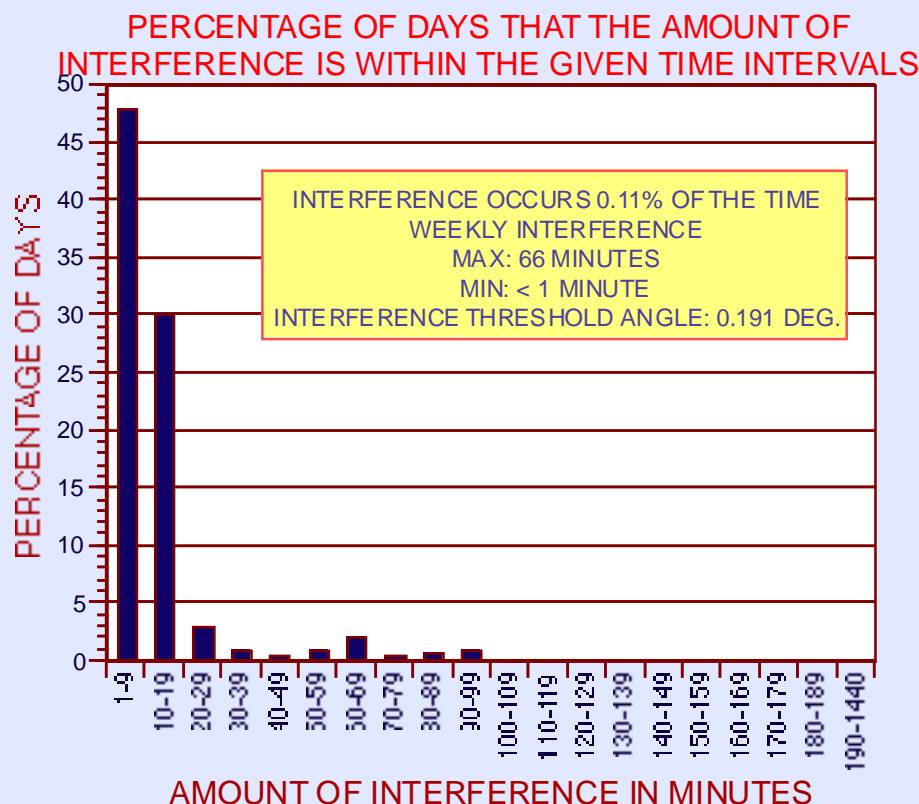




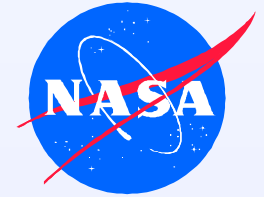
# Sample Analyses

## ■ Interference Statistics

- Calculates the magnitude of interference, location of interference, interference timelines, and interference statistics due to the emissions of all interference sources

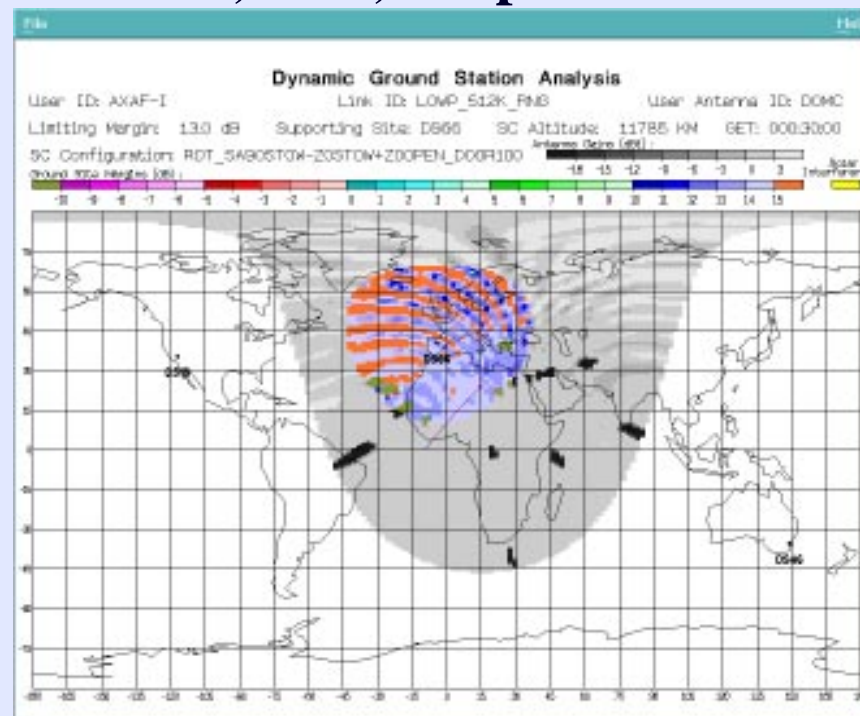


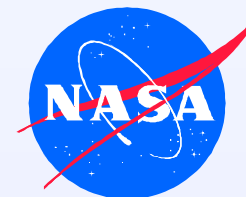
# Sample Analyses



## ■ Communications Performance

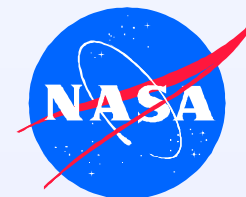
- Calculates the signal degradation from propagation effects, vehicle dynamics, antenna offpointing, and other parameters
- Calculates the BER or signal margin as a function of ground location, time, or spacecraft orientation





# **CAGE Standard Outputs**

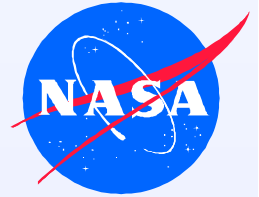
- **Timelines**
- **Histograms**
- **Probability Density Functions (PDFs)**
- **Cumulative Density Functions (CDFs)**
- **Contour Plots**
- **Dynamic 3-D displays**



# **Interactive simulations**

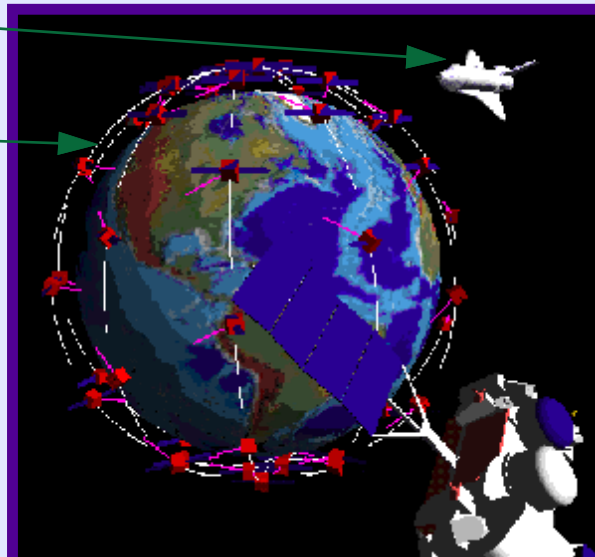
- **Users can interactively point a spacecraft antenna, open cargo bay doors, rotate a solar panel, or tumble the spacecraft and immediately see the effects on the screen**

# Display of Simulation Results

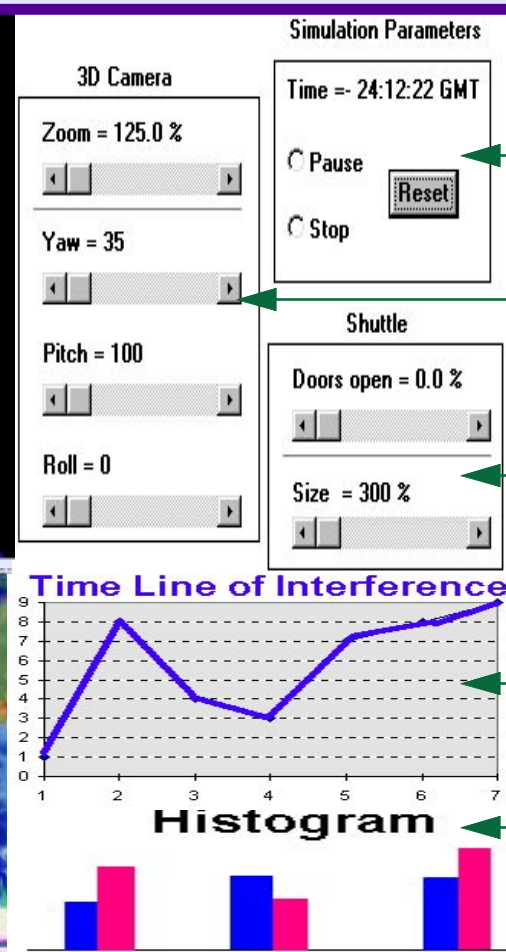
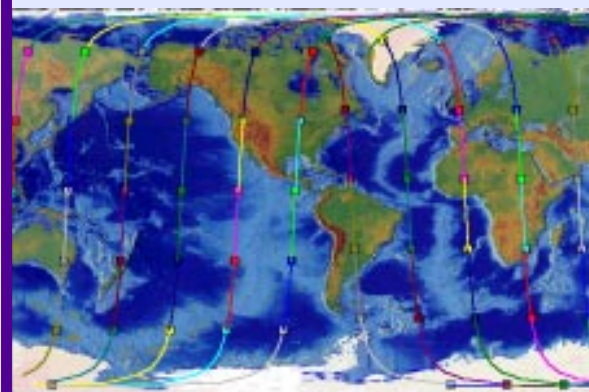


3D Animation

3D Data Visualization



Contour Plots



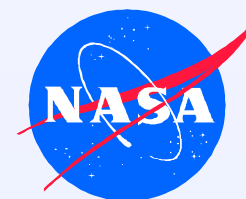
Simulation Controls

Camera Control

Interactive Simulation Controls

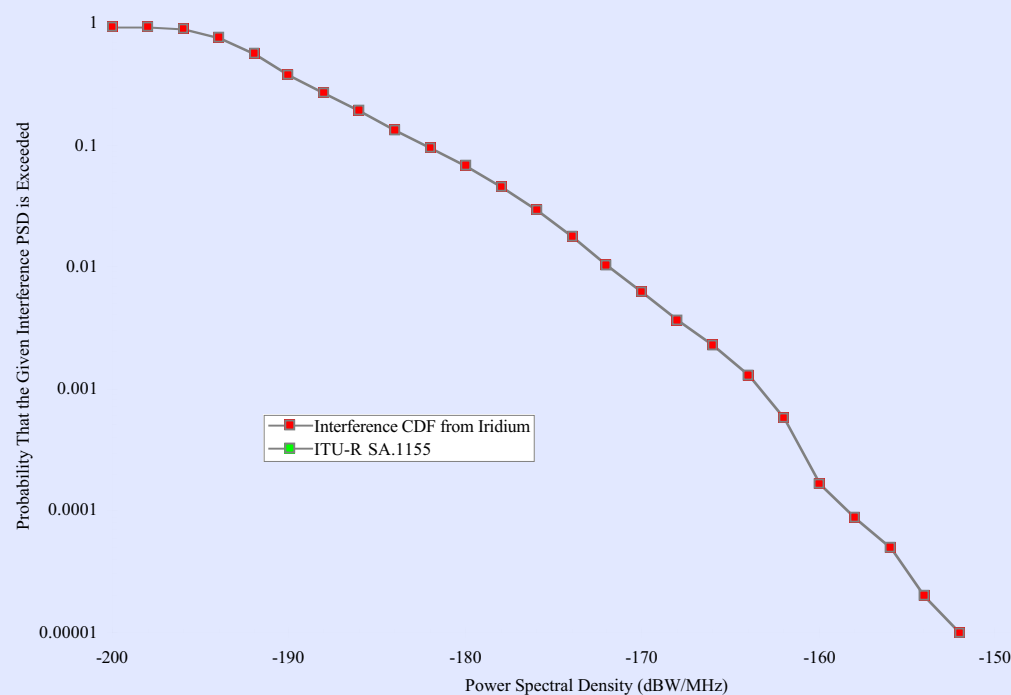
Timelines

Histograms

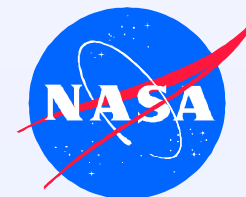


# Example

- Assess interference statistics at Tracking Data Relay Satellite System (TDRSS) user spacecraft from Iridium ISL emissions



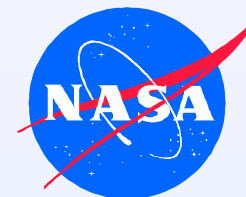




# PC System Requirements

- IBM compatible PC with Windows 95 or Windows NT
- Minimum: 486 processor with a 25 MHz clock speed
- Recommended: Pentium with 90 MHz clock speed

# Comparison with Other Simulation Tools



| Simulation Tool | Description  | Block Diagram Editing | Simulation Tool | View Results Graphically | Supports Static Simulations | Supports Dynamic Simulations | Supports 3-D Graphics | Can Calculate Interference Statistics and BER | Can Calculate Multipath | Supports Interactive Simulations |
|-----------------|--|-----------------------|-----------------|--------------------------|-----------------------------|------------------------------|-----------------------|---|-------------------------|----------------------------------|
| CAGE            | Dynamic simulation tool for modeling all aspects of space and terrestrial systems      | √                     | √               | √                        | √                           | √                            | √                     | √   | √                       | √                                |
| SPW             | Primarily a static simulation tool for modeling hardware and signal processing systems | √                     | √               | √                        | √                           | -                            | -                     | √   | √                       | -                                |
| STK             | graphical tool for analyzing and visualizing satellite systems                         | -                     | √               | √                        | √                           | √                            | √                     | -   | -                       | -                                |

**CAGE is the most powerful and versatile simulation tool available for assessing communication systems performance in a dynamic environment**